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Inflation at Risk (IaR): The Case of a Hard-Pegged Exchange Rate Regime*

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Abstract

This paper examines how inflation risks have evolved over time in a hard peg exchange rate regime (i.e., Jordan). Quantile regressions show a general increase in upside inflation risks over time, reflecting inflationary processes since 2006, which is consistent with the adoption of the oil-derivatives pricing equation by the Jordanian government. Substantial non-linearities have evolved since then. Results indicate that future core inflation distribution has become more volatile, positively skewed, has fatter tails, and has experienced a rightward shift.

Keywords: Inflation Risks; Quantile Regression; Pegged Exchange Rate Regimes.

JEL classification: C21, C53, E31, E44.

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"While the economic response has been both timely and appropriately large, it may not be the final chapter, given that the path ahead is both highly uncertain and subject to significant downside risks." ***Jerome H. Powell, May 13, 2020.***

1. Introduction

Since COVID-19 shock, price pressures have intensified worldwide, as demand is recovering, supply problems persisted longer than expected, and commodity prices surged (Queyranne *et. al*., 2022; Koch and Noureldin, 2023). The precedent war in Ukraine intensified these risks, which points to the tail risks to inflation outlook. Indeed, we started to hear a non-linear response of inflation to monetary policy. Powell's quote is an excellent reminder that, in the presence of tail risks, the conditional inflation mean does not necessarily adequately represent inflation outlook

We are at a point in time, in the business cycle, where officials are comfortable admitting they have made mistakes, whereas central bankers are pleased to talk about their forecast errors. On top of that, the International Monetary Fund (IMF) is publishing work that explains why it failed to predict the surge in inflation recently (Koch and Noureldin, 2023).

What can we learn from this? The Phillips curve linkages seem to be breaking down (Lopez-Salido and Loria, 2022). And this is not new, there is a stream in the literature that questions this relation, claiming that the Phillips curve is flat, typically attributed to changes in inflation expectations, and was thought to have contributed to the period of high inflation and high unemployment in the late 1970s. Consistent with Queyranne *et. al*., 2022; and Banerjee *et. al*., 2020, we find that almost all the macroeconomic factors covered under the "Phillips curve umbrella" are still at work, however, in the tails of inflation distribution.

Even if the best forecasting model cannot say precisely how or when a shock will strike, an economy better be aware of its vulnerabilities… so it will be resilient. This paper employs the Value-at-Risk statistic and applies it to inflation; called "Inflation-at-risk" (IaR), which quantifies the potential risk of inflation forecasts. This statistic can be seen as a better way that captures inflation outlook beyond the point-forecast. Interestingly, IaR looks at the entire distribution of future inflation; including the unobserved components embedded in observed frequencies and hence distribution. By doing that, we consider not only the baseline expected inflation but also the risks surrounding it.

We show that the response of the tails and the median of the inflation distribution reveals a more complete picture of the effects that real and financial shocks impinge on inflation. The objective of this paper is to see what conclusions can be drawn from a closer look at the entire conditional inflation distribution, using data for Jordan.

First, this paper used augmented Phillips curve for open economy as in (Banerjee *et. al*., 2020; and Queyranne *et. al*., 2022) as key drivers of two quarters (2Q)-ahead / four quarters (4Q)-ahead core inflation in Jordan, using quantile regression to analyze inflation dynamics. By doing that, this paper showed that it is evident that 2Q-ahead and 4Q-ahead core inflation exhibit significant nonlinearities, with the impact of regressors varying across quantiles of the core inflation predictive distribution. The results for 2Q-ahead core inflation show that real depreciation increases upside inflation risk, whereas larger pass-through of world commodity prices to domestic prices in a context of high inflation is evident in the right tail of predictive core inflation. Moreover, high long-term inflation expectations tend to shift the entire distribution to the right. Yet, and consistent with Banerjee *et. al*., (2020); and Queyranne *et. al*., (2022), the modal outlook for inflation seemed to remain insensitive to the real activity, or output gap. Overall, macroeconomic developments work in the right tail of the conditional core inflation distribution (e.g., Queyranne *et. al*., 2022), with its right tail being the most sensitive to macroeconomic shocks. Interestingly, the 4Q-ahead core inflation using quantile regression showed similar results.

Finally, the paper fits a t-skewed distribution using the estimated conditional quantiles (Azzalini and Capitanio, 2003), for two periods, before and after 2006q1, where we find a structural break in the data, which is consistent with the adoption of oil-derivatives pricing equation by the government. The results indicate that the future core inflation has become more volatile, right skewed, has fatter tails, and has tilted to the right. All of which may indicate increased inflation risks, over time.

The paper contributes to the literature in two folds; first, to our best knowledge, this is the second paper that applies the Inflation-at-Risk framework to the Middle East and Central Asia countries, and the first to Jordan; a case of a hard pegged exchange rate regime. In this regard, the empirical results of the paper are consistent with the literature (Queyranne *et. al*., 2022; Banerjee *et. al*., 2020), however, this paper is different as it took the real effective exchange rate (REER) gap, within the Phillips curve framework, instead of the changes of nominal exchange rate, to account for the uniqueness of exchange rate regime. Interestingly, this paper found that commodity prices are large determinants of future inflation, while the exchange rate is more muted given the fixed exchange rate regime. In particular, real depreciation increases upside inflation risk, in the 2Q-ahead core inflation, but not in the 4Q-ahead core inflation, indicating that foreign (imported) prices have limited effects in the near term. Second, it adds to the "Value-at-Risk" literature, namely, Lopez-Salido and Loria, 2022; Banerjee *et. al*., 2020; Queyranne *et. al*., 2022; and Prasad et. Al., 2022, among others.

The paper is organized as follows. Section II reviews the literature on inflation-at-risk. Section III presents some stylized facts on monetary policy in Jordan, Section IV discusses the data, and Section VI presents the empirical approach and portrays the results. Section V discusses policy implications. And Section VII concludes.

2. Literature Review

Andrade, Ghysels, and Idier (2012) introduced the "inflation-at-risk" as a measure of (left and right) tail risks to inflation using survey-based density forecasts. They showed that the position and asymmetry of inflation risks matter, and it evolves over time. Kilian and Manganelli (2007, 2008) derive inflation risk measures by optimizing agent's preferences with respect to inflation. In a cross-section of countries, Cecchetti (2008) computes t-distribution approximations to deviations of log GDP and price level from their trends and claims that asset price booms raise both growth and inflation risks. Manzan and Zerom (2013) find that adding macroeconomic variables into quantile regressions enhances the accuracy of inflation density forecasts. Galvão and Owyang (2018) find that financial conditions have robust effect on inflation using factor-augmented smooth-transition vector autoregressive model (FASTVAR). Ghysels, Iania, and Striaukas (2018) construct measures of inflation risk using a Quantile Autoregressive Distributed Lag Mixed-Frequency Data Sampling (QADL-MIDAS) regression model and find that they hold information about actual future inflation. Adams *et. al.* (2021) set up risks around consensus inflation forecasts.

In another stream of literature, Adrian *et. al.* (2019) was the first paper that utilizes the Value-at-Risk and transpose it to macroeconomic forecasting to project the conditional distribution of future real GDP growth as a function of financial conditions index, called Growth-at-Risk (GaR). This paper was revolutionary as it proposed a relatively easy approach to project the density of future real GDP growth. Based on a two-step semi-parametric approach: first, the quantile regressions framework, as future GDP growth is regressed on a set of current macro-financial conditions index. Second, fiting a continuous t-skewed distribution on the conditional quantiles estimated in the first step. Adrian *et. al*. (2019) find significant non-linearities across quantiles, with lower quantiles exhibiting stronger variation, while the upper quantiles being stable over time, which suggest that financial conditions have strong predictive power to signal crises.

Building on Adrian *et. al*. (2019) approach, Lopez-Alido *et. al*. (2022) investigates the tail risks to the inflation outlook in the US since 1970s, using quantile regressions. The baseline quantile regression model is an augmented Phillips Curve model with five main variables that capture price stickiness (lagged average inflation), forward-looking term (long-term inflation expectations), labor market frictions (unemployment gap), changes in relative prices (quarterly change in relative import prices), and financial conditions (credit spreads). The paper finds that tight financial conditions carry significant downside inflation risks.

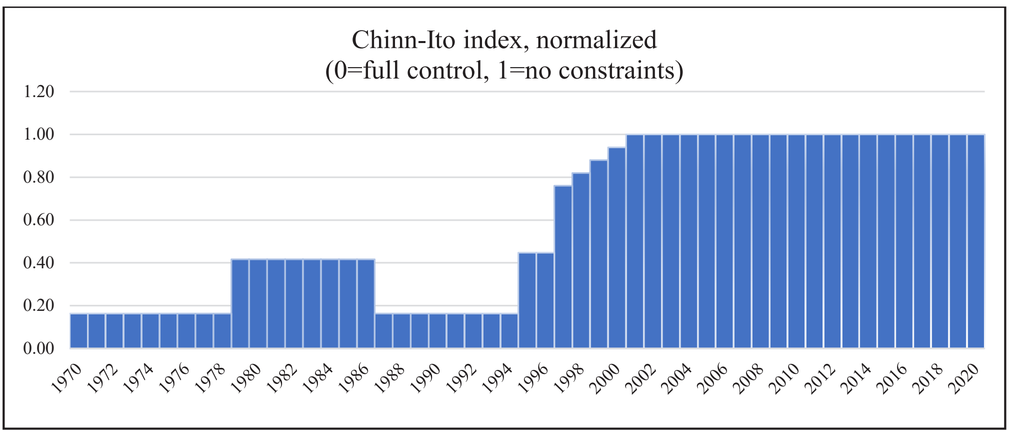
Banerjee *et. al.* (2020) extends Adrian *et. al.* (2019) approach to a cross-section of advanced and emerging economies using panel quantile regressions, with fixed effects. They fit a continuous skewed t-distribution on the discrete conditional quantiles set. The quantile regressions specification features an open-economy Phillips Curve, capturing output (real GDP growth or the output gap), current inflation, the exchange rate (change in the nominal effective exchange rate), the change in oil price in domestic currency, and financial conditions (the realized volatility in equity returns-VIX). The authors find that upside inflation risks have declined over time, reflecting successful adoption of inflation targeting regimes. Significant non-linearities is evident in emerging market economies, with substantial exchange rate depreciations associated with upside inflation risks, while tighter financial conditions increase on both tails.

In a recent paper, Queyranne et. al. (2022) builds on Banerjee et. al. (2020) approach to a cross-section of Middle East and Central Asia countries using panel quantile regressions, with fixed effects. Then, they fit a continuous skewed t-distribution. Their quantile regressions specification features an open-economy augmented Phillips Curve, as follows: Output (industrial production or the output gap), current headline inflation, the exchange rate (change in the nominal effective exchange rate), a commodity price index (Goldman Sachs Global Commodity Price Index), and inflation expectation. Their results are consistent with Banerjee et. al. (2020).

3. Jordanian monetary policy: Policy and market rates

Jordan adopts a de-facto fixed exchange rate regime since 1995, at a mid-rate of JD 0.709 per USD, with full capital and financial mobility, as indicated by the Chinn-Ito index [Figure 1][1]. Given the fixed exchange rate regime, the CBJ pursues monetary and price stability objectives. To maintain the peg, the Central Bank of Jordan (CBJ) keeps a margin of roughly around 200 basis points above the Fed Fund Rate (FFR) and intervene in the FX markets as needed.

Figure 1. Chinn-Ito Index



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[1] Chinn-Ito index is an index measuring a country's degree of capital account openness. The index was initially introduced in Chinn and Ito [Journal of Development Economics, 2006], which is based on indicator variables that codify the tabulation of restrictions on cross-border financial transactions reported as in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).

The adopted operational framework relied upon a corridor system. The corridor system consists of an overnight repurchase agreement interest rate (or Repo rate – the ceiling of the corridor system), currently at 8.0 percent, and an overnight deposit interest rate (or Window rate – the floor of the system), currently at 7.0 percent. In addition, the CBJ has the 'CBJ main' rate, at which it can manage liquidity; currently 25 basis points above the window rate, and mirrors it, as banks are diagnosed by excess liquidity, which is mainly deposited in the CBJ's Window rate[2].

Such excess liquidity challenges the development of Jordan's money market. Although the monetary policy framework has been successful in achieving the operational target as short-term interest rates remained close to the overnight window rate. However, the persistently high excess liquidity in the money market (invested in the window rate) reduces the need for interbank transactions, and exerts challenges to liquidity management, in such a way that excess liquidity disincentives the market to actively manage liquidity, using more robust instruments (i.e., repos). In this regard, the CBJ issued certificates of deposits (CDs) of JD 700 million, since August 2022, to further tighten the monetary policy stance and manage excess liquidity.

4. Data sample

The paper uses core inflation (π_t^*) data obtained from the Central Bank of Jordan (CBJ) database, which is published on the CBJ's website. Expected inflation (π_t^{LTE}) is the 5-year ahead IMF forecast of Jordan headline CPI inflation, obtained from the IMF World Economic Outlook database[3]. Real output gap ($\hat{y}_t$)[4] is used to proxy domestic inflationary pressures, while Real Effective Exchange Gap ($\widehat{reer}_t$)[5] is used to proxy inflationary pressures coming from abroad, both are estimated using Jordan's Quarterly Projection Model (QPM)[6], as the difference between the actual and trend of the variable, where the trend variable is estimated as a Kalman-

[2] These rates as of May 17, 2023.

[3] IMF WEO Inflation forecasts are an annual average index produced twice a year which has been linearly interpolated at a quarterly frequency, to match the frequency of the data.

[4] A hat above the variable, $\hat{x}_t$, indicates that the variable is a gap; a deviation from the equilibrium level.

[5] CPI-based REER is constructed based on the weights of Jordan's trading partners. In Jordan's QPM (JAM 2.0), An increase in the index indicates depreciation, which corresponds to a gain in competitiveness.

[6] A semi-structural macroeconomic model (JAM 2.0), has developed as a Forecasting and Policy Analysis System (FPAS), geared to provide reliable macroeconomic analysis, and forecasting to support monetary policy recommendations. It belongs to the family of policy-oriented central bank's Quarterly Projection Models (QPMs), customized to reflect the uniqueness of the Jordanian economy, within a pegged exchange rate regime (Al-Sharkas et.al, 2023).

filtered underlying potential of a variable. $\widehat{reer}_t$ is defined as the relative price of domestic-and-foreign goods (comprised of a nominal effective exchange rate multiplied by a foreign-to-domestic price ratio, expressed in logarithms). A real depreciation ($\widehat{reer}_t > 0$)[7] means that we are importing inflation from abroad. Finally, we use Goldman Sachs Global Commodity Price Index ($GSCI_t$) to proxy commodity inflationary pressures. All data used is quarterly data and covers the period of 1995q1 till 2022q2. Table 1. describes the data sources used for each variable.

Table 1. Data and data sources.

Variable	Definition	Sources
Core Inflation	Z-score of Y-o-Y changes in core inflation	CBJ website
Output Gap	Z-score of percent difference between Real GDP and Potential GDP	Jordan QPM
Reer Gap	Z-score of Real Effective Exchange Gap, '+' for Depreciation, '-' for Appreciation	Jordan QPM
Commodity Price Index	Z-score of Goldman Sachs Global Commodity Price Index	Bloomberg
Inflation Expectation	Z-score of 5-year ahead forecast of IMF CPI inflation	IMF World Economic Outlook database

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5. Methodology and empirical results

5.1. Methodology

Adrian *et. al.* (2019) is the first who transposes the Value-at-Risk (VaR) to macroeconomic forecasting, to project the conditional distribution of future real GDP growth as a function of current macro-financial conditions. This paper utilizes this procedure and applies it to the predictive distribution of core inflation. Most papers use headline inflation; however, as

[7] A positive reer gap ($\widehat{reer}_t > 0$) indicates a real depreciation beyond its equilibrium level.

monetary policy implicitly targets core inflation, this paper uses core inflation instead of the headline inflation. In addition, core inflation is relatively stable compared to headline inflation. The procedure entails a 2-step approach: first, estimating the quantile regression, to examine how the tails of the predictive distribution of core inflation react to global "push" and domestic "pull" factors, characterizing risks for near-and-medium-term inflation dynamics. Having said that, focusing on the tails of the predictive distribution; upper tail (high inflation), and lower tail (low inflation) gives insights for policymakers regarding the sources of future inflationary/dis-inflationary pressures, and how it evolves.

Following Banerjee *et. al.* (2020), and (Queyranne *et. al.*, 2022) approach to inflation risks, the paper models an augmented Phillips curve with open economy variables as key drivers of future 2Q-ahead (and 4Q-ahead) core inflation in Jordan, using the quantile regression framework, as follows:

$$\pi^{*q}_{t+h} = \beta^q_0 + \beta^q_1 \pi^*_t + \beta^q_2 \pi^{LTE}_t + \beta^q_3 \widehat{reer}_t + \beta^q_4 GSCI_t + \beta^q_5 \widehat{y}_t + \varepsilon^q_{t+h} \qquad (1)$$
$$h \in \{2,4\}$$

Where π^{*q}_{t+h} represents future hQ-ahead core inflation for quantile, here quantile means percentile, i.e., $q \in \{0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9\}$. Conditional quantiles are estimated simultaneously and the variance–covariance matrix of the estimators is obtained by bootstrapping, with 1000 iterations. All variables are normalized using z-score, hence, β^q coefficient equals the size of the σ −movement in hQ- ahead core inflation, associated with a one σ − movement in the variable.

The model specification is close to the one performed by Queyranne *et. al.* (2022), with a couple modifications, the paper replaced the nominal effective exchange rate (Neer)[8] by real effective exchange rate gap, as for a country like Jordan, $\widehat{reer}_t$ is a better proxy for foreign inflation, and also the choice of the dependent variable is different, this paper replaced the headline inflation by the core inflation, as the core inflation is less volatile than the headline consumer price index (CPI). In addition, monetary policy targets price stability, therefore, the choice of core inflation is better.

[8] $Reer = Neer . \frac{P*}{P}$

Second, this paper derived the predicted core inflation distribution by fitting a continuous skewed t-distribution on the conditional quantiles estimated (Azzalini and Capitanio, 2003). The distribution of the predicted future core inflation is estimated based on the information derived from the augmented Philips curve, therefore, the choice of the variables for explaining their relationship with future core inflation is crucial.

A distribution fitting allows to obtain a complete picture of inflation risks and to calculate the associated risk metrics, such as VaR. We use the t-skew parametric fit approach as in the IMF-GaR tool developed by Prasad et. al. (2019). The choice of the t-skew family is popular, especially in finance (Adcock *et. al.* (2015)) and has been progressively used in macroeconomics. Skewed t-distributions have appealing features (i.e., asymmetry, fat tails) in a parsimonious framework (Azzalini and Capitanio (1994). The fit is done by minimizing the distance between the empirical quantiles and the theoretical quantiles of a skewed t-distribution. It minimizes the sum of asymmetric penalties $(1-q)|e|$ for overprediction and $q|e|$ for underprediction ($e = y_i - x_i'\beta^q$). This minimization problem is set up as a linear programming problem and is solved with linear programming techniques, as in Koenker (2005). More formally, quantile regression estimators minimize the following function:

$$Q(\beta^q) = \sum_{i:y_i \geq x_i'\beta}^{N} q|y_i - x_i'\beta^q| + \sum_{i:y_i < x_i'\beta}^{N} (1-q)|y_i - x_i'\beta^q| \tag{2}$$

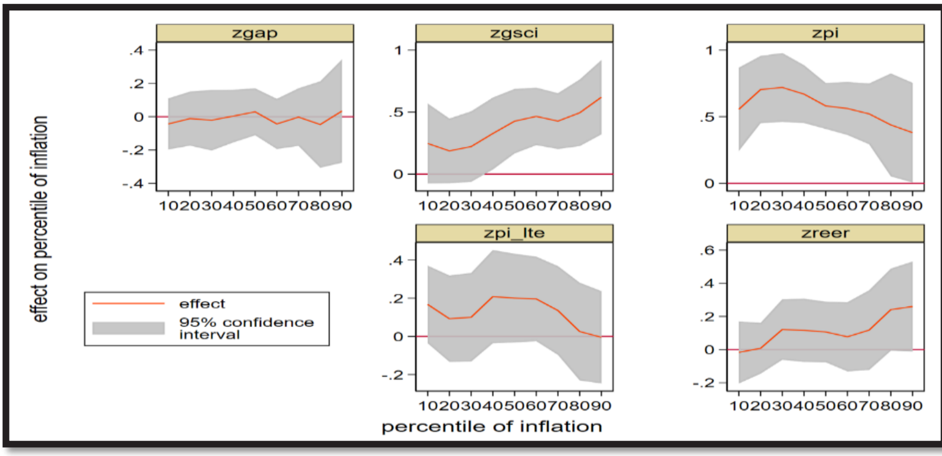
$$Q(y|x) = x_i'\beta^q = \beta_0^q + \beta_1^q\pi_t^* + \beta_2^q\pi_t^{LTE} + \beta_3^q\widehat{reer}_t + \beta_4^q GSCI_t + \beta_5^q\hat{y}_t + \varepsilon_{t+h}^q \tag{3}$$

5.2. Empirical Results

5.2.1. Quantile regression framework

Quantile regression allows for nonlinearity (Prasad *et. al.*, 2019). Such that, the effects of the independent variables may vary over quantiles of the conditional distribution, which is an important advantage of quantile regression over mean regression. The results of quantile regression for 2-quarters ahead and 4-quarters ahead of the future core inflation are presented in the following figures (figure 2 and 3). The below figures present evidence of significant nonlinearities across quantiles.

Figure 2. the 2Q-ahead Core inflation.



Prepared by the author.

Figure 3. the 4Q-ahead Core inflation

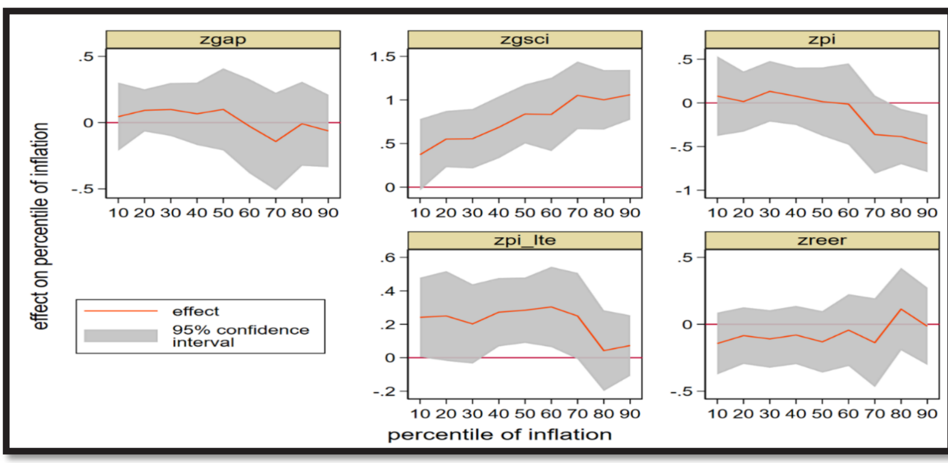


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Table 2. and Table 3. present the detailed quantile regressions results, presented in a heatmap, for 2-quarters ahead, and 4-quarters ahead of the future core inflation, respectively, along with the OLS estimate of the underlying coefficient, to allow comparison.

Table 2. 2Q-ahead Core Inflation-Quantile coefficients, by regressor.

Table 2. presents the 2Q-ahead Core Inflation-Quantile coefficients, by regressor. The sample period covers 1995q1 till 2022q2. For a given variable, the heat map below shows the coefficients for each variable at different quantiles. π^*_{t+2} represents two quarters ahead core inflation, π^*_t represents core inflation, $\widehat{reer_t}$ is the real effective exchange rate gap ($\widehat{reer_t} > 0$ represents real depreciation), $\hat{y}_t$ is the output gap, $GSCI_t$represents Goldman Sachs Global Commodity Price Index , π^{LTE}_t is the five year ahead forecast of IMF CPI inflation. All variables are standardized, using z-scores. The last column compares the OLS estimates using Newey-West standard errors, using four lags, to account for any potential autocorrelation. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. The constant is omitted from the results as it is insignificant.

	q^{10}	q^{20}	q^{30}	q^{40}	q^{50}	q^{60}	q^{70}	q^{80}	q^{90}	β^{OLS}
π^*_t	0.556***	0.704***	0.720***	0.670***	0.581***	0.562***	0.521***	0.438**	0.380**	0.527***
$\widehat{reer_t}$	-0.017	0.008	0.121	0.116	0.106	0.077	0.118	0.241*	0.260*	0.105
$\hat{y}_t$	-0.043	-0.011	-0.021	0.004	0.029	-0.043	-0.002	-0.047	0.034	-0.017
$GSCI_t$	0.247	0.187	0.222*	0.327**	0.426***	0.465***	0.427***	0.494***	0.620***	0.439***
π^{LTE}_t	0.167	0.093	0.1	0.208	0.2	0.196*	0.135	0.025	-0.005	0.130
$Pseudo\ R^2$	0.396	0.3988	0.4109	0.4213	0.4311	0.4404	0.4624	0.4683	0.4746	0.43
obs	92	92	92	92	92	92	92	92	92	92

Less Inflationary

More Inflationary

Prepared by the author.

Table 2. and Table 3. present the detailed quantile regressions results, presented in a heatmap, for 2-quarters ahead, and 4-quarters ahead of the future core inflation, respectively, along with the OLS estimate of the underlying coefficient, to allow comparison.

quantiles. The dominance of backward-looking inflation indicates significant inertia in price setting in the near term. Current core inflation has a strong impact at the left tail of the distribution, showing a larger effect when inflation is low. This result reflects successful disinflationary processes, which is in line with the price stability mandate of the CBJ, as keeping inflation low and stable is crucial to avoid self-reinforcing inflation dynamics.

REER gap has a positive coefficient through quantiles, with explanatory power in the right tail of the distribution, i.e., high inflation, pointing that real depreciation increases upside inflation risk. The domestic output gap is muted across quantiles. Whereas commodity prices display larger coefficients at the right tail of the distribution, pointing to a larger pass-through to domestic prices in a context of high inflation. Long-term expected inflation influences the higher quantiles rather than on the lower quantiles of the conditional distribution, indicating that high past inflation experiences tend to shift the distribution to the right.

When comparing these results to the OLS estimates (in the last column of the Table), estimated by Newey-West standard errors, using four lags, assuming that the potential autocorrelation in the data does not go beyond the window of four quarters. Noting that the backward looking and commodity prices coefficients have explanatory power to the 2Q-ahead core inflation, and we lost significance for the REER gap and the long term expected inflation.

Table 3. 4Q-ahead Core Inflation-Quantile coefficients, by regressor.

Table 3. presents the 4Q-ahead Core Inflation-Quantile coefficients, by regressor. The sample period covers 1995q1 till 2022q2. For a given variable, the heat map below shows the coefficients for each variable at different quantiles. π_{t+4}^{*} represents four quarters ahead core inflation, π_t^{*} represents core inflation, $\widehat{reer}_t$ is the real effective exchange rate gap ($\widehat{reer}_t > 0$ represents real depreciation), $\hat{y}_t$ is the output gap, $GSCI_t$represents Goldman Sachs Global Commodity Price Index , π_t^{LTE} is the five year ahead forecast of IMF CPI inflation. All variables are standardized, using z-scores. The last column compares the OLS estimates using Newey-West standard errors, using four lags, to account for any potential autocorrelation. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. The constant is omitted from the results as it is insignificant.

	q^{10}	q^{20}	q^{30}	q^{40}	q^{50}	q^{60}	q^{70}	q^{80}	q^{90}	β^{OLS}
π_t^{*}	0.079	0.016	0.133	0.077	0.015	-0.013	-0.362*	-0.385*	-0.464***	-0.162
$\widehat{reer}_t$	-0.144	-0.085	-0.109	-0.08	-0.131	-0.044	-0.138	0.114	-0.015	-0.005
$\hat{y}_t$	0.045	0.092	0.099	0.067	0.01	-0.028	-0.143	-0.009	-0.062	0.050
$GSCI_t$	0.373*	0.552**	0.556***	0.686***	0.840***	0.835***	1.053***	1.002***	1.06***	0.846***
π_t^{LTE}	0.241*	0.250*	0.202*	0.272**	0.284***	0.304**	0.25	0.043	0.073	0.119
$Pseudo\ R^2$	0.234	0.267	0.269	0.263	0.265	0.280	0.327	0.395	0.455	0.31
obs	92	92	92	92	92	92	92	92	92	92

Less Inflationary

More Inflationary

Prepared by the author.

By looking at Table 3, and in the same manner, it’s evident that 4Q-ahead core inflation exhibits nonlinearities, however, the story is marginally different, compared to the 2Q-ahead core inflation, However, it completes the picture. As shown in Table 3. The backward-looking inflation has a negative coefficient with explanatory power in the right tail, as the inertia in the price-setting process may gradually dissipate over time. Contrary to the results of the future 2Q-ahead core inflation analysis, the forward-looking inflation displays a stronger effect, in line with long-term inflation expectations play a prominent role in controlling inflation, therefore, anchoring inflation expectations is critical to control inflation in the longer run. This result is crucial, reflecting evidence of anchoring expectation. Although Jordan is not an inflation targeter, neither it has surveies of agents’ inflation expectation, however, the channel is there, through labor market[9]. The largest coefficient is for commodity prices, with a larger coefficient in the right tail of the distribution, indicating higher pass-through to domestic prices, when inflation is high, albeit with a larger coefficient for 4Q-ahead core inflation, compared to 2Q-ahead core inflation analysis. The output gap and REER gap are insignificant overall. Comparing these results to the OLS estimates, the commodity prices coefficient is significant, assuming linearity, indicating that the Phillips curve linkages seem to be breaking down, however, tolerating nonlinearity, the Philips curve relation works in the tails of the inflation distribution.

Overall, this analysis can point out the main sources of predicted inflation in the near to medium term. Thus, it can be used as a useful tool for policymakers, that gives insights into the main sources of near-term forecasted inflationary pressures, and recommends when to react, or not to react.

[9] The author used 5-year ahead inflation as in the IMF staff country report for Jordan, interpolated to quarterly frequency, which represents professional forecasters’ expected inflation.

Lastly, this paper provides the 2Q-ahead, and 4Q-ahead core inflation forecasts, across quantiles, presented in Table 4.

Table 4. Forecasts of Core inflation[10]

Forecasts	π^{q10}	π^{q20}	π^{q30}	π^{q40}	π^{q50}	π^{q60}	π^{q70}	π^{q80}	π^{q90}	QPM
2022q2	1.35	1.66	2.01	2.20	2.49	3.01	3.63	4.23	4.97	2.1[11]
2022q4	2.75	2.98	3.37	3.51	3.71	4.28	4.60	5.06	6.11	5.4
2023q2	2.10	2.78	2.80	2.85	3.04	4.04	4.70	5.45	6.16	5.9

Prepared by the author.

The rows of Table 4 present the projections using quantiles regression as in equation (1), across different quantiles, and the last column presents the point forecasts using Jordan's QPM model[12].

One can notice that, in the first row, the 2.1 percent lies between the 30th and 40th percentiles. However, if we consider the 2Q-ahead forecasted core inflation (at that time-2022q4), the projected 5.4 percent lies between the 80th and 90th percentiles. The actual number came up lower than expected, reaching 4.3 percent, which is exactly the 60th percentile, which partly may reflect the effect of the JD 700 million CDs issued in August 2022, to further tighten

[10] Projections as of November 1, 2022
[11] 2.1 % represents the real time data (actual data).
[12] Jordan's QPM is viewed as a reliable analytical framework that provides macroeconomic analysis and forecasting under a hard pegged exchange rate regime.

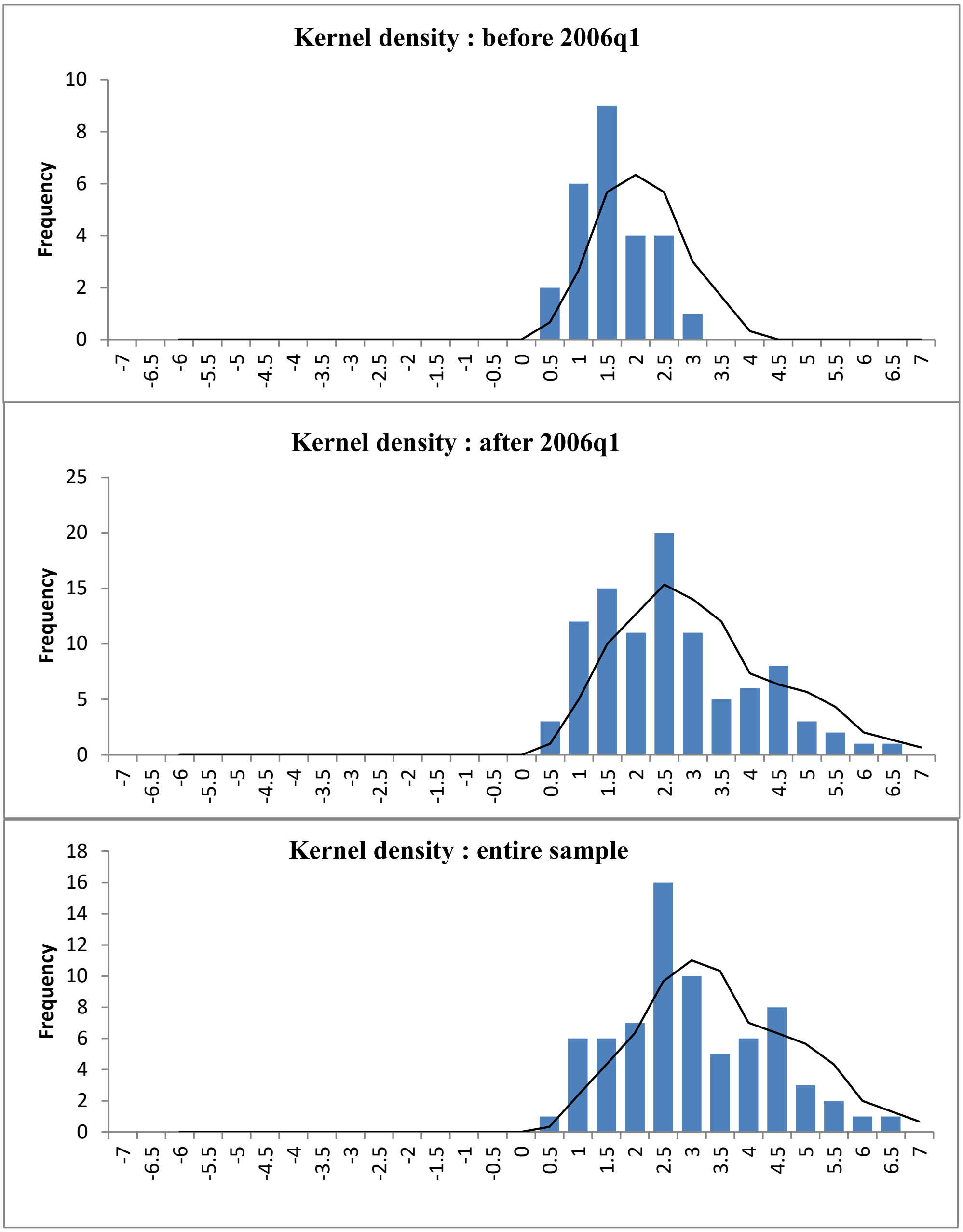
monetary policy, on top of that, the effect of changes in initial conditions, mainly, the FFR is higher by 100 basis points, than what we had in the external assumptions, at that time, indicating tighter monetary policy condition. Moreover, by looking at the 4Q-ahead forecasted core inflation (at that time – 2023q2), the projected 5.9 percent lies between the 80th and the 90th percentiles. However, if we consider the actual numbers, as of May 2023, core inflation reached 4.1 percent, which lies between the 60th and 70th percentiles. It's evident that we are on the upside tail of the forecasted core inflation distribution, indicating higher up-tail inflation risks. Hence, the point-estimate, proxied by the median of the forecast, is not necessarily adequate for inflation outlook.

5.2.2. Fitting a skewed t-distribution

To obtain a complete picture of the inflation risks, this paper fit a skewed t-distribution using the estimated conditional quantiles (Azzalini and Capitanio, 2003). To do that, first, the paper tested for parameters instability and structural breaks with unknown change points, to avoid forcing any assumptions regarding the stability of the parameters, and let the data speak. To that end, this paper used the supremum test (Andrews, 1993). Accordingly, a structural break was identified in 2006q1. This observation is in line with the introduction of the oil derivatives pricing equation by the government. Therefore, the paper defines an indicator variable "*break*", that equals 1 for the period after 2006q1, and zero otherwise, as follows:

$$break \quad = \begin{cases} 1, & date > 2006q1 \\ 0, & date \leq 2006q1 \end{cases} \tag{4}$$

Figure 4. Distributions of Future Inflation



Prepared by the author.

Figure 4 presents the distribution of 2Q-ahead core inflation before 2006q1 (the top panel), after 2006q1 (the middle panel), and the entire sample for Jordan (the last panel). The location of the distribution of 2Q-ahead core inflation has evolved significantly during the sample period. Before 2006q1 (top panel), the distribution of conditional core inflation is more peaked, centered at 1.4 percent (median equals 1.3 percent), however, it has shifted to the right for the period after the adoption of the oil derivatives pricing equation, after 2006q1 (middle panel), and it is right-skewed (mean = 2.8 percent; median = 2.5 percent), it has fatter tails and flatter distribution. These results are in line with Queyranne *et. al.* (2022). Combining these two periods, and hence these two kernels, it yields the last panel kernel distribution. The location of the distribution matters, and more importantly, how it evolved, over time. Given that, the predictive distribution of core inflation has widened, has fatter tails, right-skewed (mean = 2.4 percent; median = 2.2 percent), relative to a normal distribution. Therefore, the future core inflation has become more volatile and has tilted to the right of the distribution. All of which may indicate increased risks of higher inflation levels, over time.

Building on these results, if the CBJ decides on its inflation risk threshold to be the 90th percentile, then this statistic would be 2.3 percent in the period before 2006q1, and 4.3 percent in the period after 2006q1. Resulting in a 4.2 percent for the entire sample period.

6. Policy Implications

Inflation-at-Risk (IaR) is a better way that captures inflation outlook beyond point-forecast, which offers a piece of information, that even our best and the most complicated forecasting models cannot offer. Having said this, by using the IaR approach, central banks can decide on their inflation risk thresholds (i.e., 90 percentile, 95 percentile) to anchor expectations, efficiently.

Central banks should give more attention to tails risks, especially upside inflation risks, as it directly affects monetary policy decisions. Therefore, central banks should consider not only the linear effects, but also the nonlinear effects in the forecasting process. This would help reduce the costly deviations from the price stability (implicit) target by acting early and prudently before upside risks materialize.

Not only the upside risks, but also the downside inflation risks have essential implications for the future stance of monetary policy. Given the uncertain environment, central banks should communicate the balance of risks around their core inflation point forecasts, using heat-maps or fan-charts, up to 8 quarters, instead of publishing forecasting errors, to protect the credibility of central banks.

7. Conclusion

The impact of key drivers of core inflation is nonlinear and varies over time and across different levels of inflation. The predictive core inflation has experienced a rightward shift over time, reflecting increased risks of higher inflation levels. In particular, the distribution is becoming more positively skewed over time, indicating upside risks have become more prominent. Kurtosis has increased; fat tail risks are more prominent. Variance has also widened. Future core inflation outcomes have become more volatile and have tilted to the right of the distribution.

Applying the IaR framework to Jordan, a case of a hard-pegged exchange rate regime reveals that commodity prices have a dominant effect on future inflation risks, while the exchange rate has muted effects, given the exchange rate regime, as foreign (imported) prices, proxied by the real effective exchange rate, have limited effects in the near term.

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مخاطر التضخم (IaR): حالة نظام سعر الصرف الثابت

إعداد

د. سارة الطلافحة

آب 2023

هذه الدراسة تمثل وجهة نظر كاتبتها ولا تمثل وجهة نظر البنك المركزي الأردني أو مجلس إدارته. ولا تتحمل المؤسسة مسؤولية ما ورد في هذه الدراسة.

الملخص

تهدف هذه الدراسة الى تتبع المسار الزمني لمخاطر التضخم في الاقتصاد الأردني ضمن افتراض نظام الصرف المربوط بعملة واحدة، وقد أظهرت نتائج تقدير نموذج الانحدار المئيني (Quantile regressions) ضمن الاتجاه العام أن هنالك زيادة في مخاطر التضخم المحتملة مع مرور الوقت، وجاء ذلك انعكاساً للضغوط التضخمية التي ظهرت منذ عام 2006 في ضوء تبني الحكومة الأردنية معادلة تسعير المشتقات النفطية، كما وأظهرت النتائج تغيرات غير خطية في مسار مخاطر التضخم منذ ذلك الحين، واشارت النتائج ايضاً ان التوزيع الاحتمالي المتوقع للتضخم الأساسي في المستقبل يتصف بالتذبذب العالي، وموجب الالتواء، ويحمل مخاطر القيم المتطرفة وشهد إزاحة إلى اليمين.

الكلمات الدالة: مخاطر التضخم، نموذج الانحدار المئيني، نظام سعر الصرف الثابت.

JEL classification: C21, C53, E31, E44.